A Clinical Algorithm for the Management of Abnormal Mammograms

A Community Hospital's Experience

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Mammography is an important tool in the early detection of breast cancer, but its use has been criticized for stimulating the performance of unnecessary breast biopsies. We retrospectively reviewed the results of breast biopsies preceded by abnormal mammograms at a community hospital for three 5-month periods—baseline, postintervention, and follow-up—to determine the effectiveness of algorithm-based care for patients with an abnormal mammogram. Cases in which there was a definite or implied recommendation for biopsy by a radiologist revealed a baseline positive predictive value of 4% (2/45), a postintervention positive predictive value of 21% (9/42), and a follow-up–phase positive predictive value of 18% (5/28). A Fisher's exact test of the preintervention and postintervention positive predictive values after an abnormal mammogram with a "recommendation for biopsy" was significant (n = 87, *P* = .023). A Kruskal-Wallis analysis of variance to determine if there had been an increase in the mean lesion size of breast cancers detected over the 3 study periods was not significant. The results of this study suggest that developing a clinical algorithm under the leadership of an opinion leader combined with continuing medical education efforts may be efficacious in reducing the incidence of unnecessary surgical procedures.

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Breast cancer is the most common form of cancer diagnosed in women and the second leading cause of cancer death for women in the United States.[1] The current age-adjusted breast cancer death rate is 20.7 per 100,000 for the United States.[2] No proven preventive method is currently available; therefore, the best hope for improving breast cancer survival is early detection and treatment of the disease.[3] Mammography is currently the most effective imaging technique for the early detection of breast cancer and a reliable method for detecting nonpalpable or occult breast malignancy.

A major criticism of mammography in the United States is the cost associated with mammographically stimulated biopsies.[4,5] One reason may be that the failure to diagnose breast cancer is one of the leading causes of malpractice suits in the United States. Some think this medicolegal pressure has led radiologists to read mammograms "defensively," thereby precipitating the performance of unnecessary biopsies.[5]

Experts in the United States commonly suggest a positive predictive value (PPV) of between 10% and 30% for breast biopsies so that occult cancers are not missed and breast cancer can be diagnosed at an early stage.[6] Two recent US studies describing PPVs for palpable and nonpalpable breast biopsies following mammography report positive rates of 19.5% and 19%.[6,7] In other western countries, however, PPVs are higher than the US recommended upper limit of 30%. In France, 43% is reported; in the Netherlands, 46%; in Australia, 56%; and, in the United Kingdom, PPVs of as high as 65% are reported.[8–11]

A review of the age-adjusted breast cancer death rates per 100,000 in other western countries reveals higher rates than those for the United States—26.8 for the Netherlands and 28.7 for England and Wales.[2] The age-adjusted breast cancer death rates per 100,000 for France and Australia, however, are 19.7 and 20.7, respectively; these rates more closely approximate the age-adjusted breast cancer death rate of 20.7 per 100,000 for the United States.[2] Clearly there is a tradeoff at a certain point (perhaps in the 50% range) in achieving high PPVs, but a PPV of greater than 30% does not necessarily result in higher breast cancer death rates.

Some notable attempts have been made to address the issue of unnecessary biopsies; one study reports a US PPV of 42.8%.[12] That study's investigators examined the

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use of statistical analysis of mammographic patterns in improving the yield of cancer in breast biopsies. Concern was expressed over the high yield, however, and it was suggested that further research be done on surgeons' decisions to do biopsies.

More than ten years ago, it was suggested that the reasons for the variation in the PPVs of mammography be investigated, either by physicians or by hospitals.[13] Variation in physicians' approach to the management of patients with mammographic abnormalities may well account for the differences found in PPVs.

At the 1993 National Conference on Breast Cancer, it was suggested that a comprehensive approach to mammography will enable physicians to avoid doing unnecessary breast biopsies and improve the early detection of breast cancer.[14]

The intervention for the current project was the project's combination of developing a clinical algorithm, an educational influential (opinion leader), and continuing medical education. The dependent measure was the PPV.

Subjects and Methods

The pilot project used a multilevel intervention regarding the algorithm-based management of patients with abnormal mammograms. The project consisted of the following:

- Educating the chief of surgery (opinion leader) in clinical algorithm development (July 1991);
- Forming a committee, chaired by the chief of surgery, with physician representatives from the family practice, pathology, radiology, and surgery sections to develop a clinical algorithm on the management of abnormal mammograms (September 1991);
- Developing a clinical algorithm based on a review of scientific literature and current practice (January 1992);
- Validating the clinical algorithm (February through April 1992);
- Providing education and print materials on the clinical algorithm to study participants (February through June 1992); and,
- Follow-up mailing of the clinical algorithm (Figures 1 through 3 [at end of report]) to the study participants (July 1993).

The two sources of data for the research portion of this project were the computer databases of the hospital's pathology department and the participating radiology medical group (the group was accredited by the American College of Radiology throughout the study periods). Cases listing no mammographic service by the group or a negative mammogram were excluded.

Research Design and Participants

Surgeons were not randomly selected, and random assignment to experimental and control groups was *im*practical. Therefore, the research used an intragroup quasi-experimental design comparison of positive breast biopsy rates.

The dependent measure was the PPVs using the total number of outpatient breast biopsy cases that met the study criteria (see "Data Collection") as the denominator.

All study participants (n = 9) were physician members of the surgery section at the community hospital with medical staff privileges for the duration of the research. The participating radiology medical group members were selected as a convenience sample (n = 13) because two of the algorithm development committee members were radiologists from this group.

Positive and negative predictive values were calculated using the total number of outpatient breast biopsy cases that met the study criteria as the denominator. Negative breast biopsy cases were defined as those meeting the research criteria but showing no evidence of malignancy on histopathologic examination and diagnosis. Positive breast biopsy cases were defined as those meeting the research criteria and showing evidence of malignancy on histopathologic diagnosis.

Data Collection

In September 1994, the research team requested a computer-generated report listing all pathology reports of outpatient breast cases from the hospital's pathology department database for the following time periods: September 1, 1990, through January 31, 1991 (preintervention phase); September 1, 1992, through January 31, 1993 (postintervention phase); and September 1, 1993, through January 31, 1994 (follow-up phase).

Cases with an admitting or preoperative diagnosis of "breast mass or lump," "breast lesion," "suspected breast carcinoma or cancer," "breast biopsy," "breast carcinoma or cancer," and "rule out breast carcinoma or cancer" were included. Cases were initially excluded for one of the following reasons:

- Previous breast cancer diagnosed in same breast as current biopsy,
- Breast tissue from plastic surgery (reduction or reconstruction) procedure,
- Dermatologic lesion(s) of the breast, and
- Pathology diagnosis included the phrase "consistent with previous biopsy site."

In December 1994, the research team requested access to the computer database of the participating radiology group. The radiology computer database was then queried with the patient's name on each breast biopsy pathology report remaining after the aforementioned study exclusion process. Cases listing a mammography service (screening, diagnostic, or ultrasonography) within a year before the biopsy were selected and the radiology records abstracted. Those breast biopsy cases with a previous abnormal mammographic report (either screening or diagnostic mammogram or ultrasonogram) were included. Those breast biopsy cases in which there was a negative mammogram or no mammographic service performed by the participating radiology medical group were excluded.

We reviewed archival medical records for the pathol-

ogy reports and radiology records of breast cases meeting the study criteria. The cases were then stratified into two subsets: those in which a radiologist "recommended biopsy," and "other"—those in which a radiologist deferred to clinical opinion.

Results

We reviewed 596 breast pathology reports for the entire study period. Of these cases, 433 were excluded because they did not meet the study criteria. A total of 163 breast biopsy cases met the study criteria for all three study phases. Of these cases, 4 (2.5%) were from men; they were included because they met all study criteria. See Tables 1 and 2 for a summary of the findings for each of the three phases of the study—preintervention (baseline), postintervention, and follow-up.

TABLE 1.— *Positive Predictive Value (PPV) for Cases Preceded by an Abnormal Mammogram*

Item	Baseline Phase	Postintervention Phase	Follow-up Phase
Sample size, No.	59	61	43
Malignant tumors detected, No.	4	12	9
Cases with abnormal mammogram, PPV, %	7	20	21

TABLE 2.— *Positive Predictive Values (PPVs) for Cases With a "Recommendation for Biopsy"**

Item	Baseline Phase	Postintervention Phase	Follow-up Phase
Sample size, No.	45	42	28
Malignant tumors detected, No.	2	9	5
Cases with "biopsy recommended," PPV, %	4	21	18

*This is a subset of the group summarized in Table 1.

TABLE 3.— *Positive Predictive Values (PPVs) by Surgeon Group*

Surgeon Group	Baseline Phase	Postintervention Phase	Follow-up Phase
Group I, PPV, %	19 (4/21)	11 (2/18)	24 (4/17)
Group II, PPV, %	0 (0/38)	24 (10/42)	18 (4/22)

Surgeons by Group

Of the nine study subjects (surgeons), six were represented in all three phases of the research. These physicians were stratified into two groups: group I comprised surgeons who were involved in the algorithm development (n = 3), and group II comprised surgeons who were recipients of algorithm education only (n = 3). Table 3 presents a summary of PPVs by groups I and II.

A Fisher's exact test of group I's PPVs for the preintervention and postintervention phases was not significant (n = 39, $P = .667$). A Fisher's exact test of group I's PPVs for the postintervention and follow-up phases also was not significant (n = 35, $P = .402$).

A Fisher's exact test of group II's PPVs for the preintervention and postintervention phases was significant (n = 80, $P = .001$). A Fisher's exact test of group II's PPVs for the postintervention and follow-up phases was not significant (n = 64, $P = .755$).

A Fisher's exact test of group I and II's postintervention PPVs was not significant (n = 60, $P = .317$).

Size of Malignant Tumors

Table 4 shows the mean lesion size of the malignant tumors detected in cases preceded by an abnormal mammogram in the preintervention, postintervention, and follow-up phases. A Kruskal-Wallis analysis to determine if there had been an increase in the mean lesion size of breast cancers detected over the three study periods was not significant (H [2, n = 25] = 2.000, $P = .368$).

TABLE 4.— *Mean Size of Malignant Lesions Detached*

Item	Baseline Phase	Postintervention Phase	Follow-up Phase
Cancers detected, No.	4	12	9
Mean lesion size, cm	1.03	1.21	1.31
Standard deviation	0.36	0.47	0.63
Range, cm	0.7 to 1.1	0.4 to 2.0	0.5 to 2.2
Cancers >2.0 cm, No.	1	1	2

Cases With 'Biopsy Recommended'

A χ^2 analysis of the total number of cases with "biopsy recommended" for the baseline and postintervention phases was not significant (χ^2 [1, n = 120] = 0.498, $P = .481$). A χ^2 analysis of the total number of cases with "biopsy recommended" for the postintervention and follow-up phases also was not significant (χ^2 [1, n = 104] = 0.035, $P = .851$).

Histopathologic Findings

Table 5 depicts the histopathologic findings by category.

TABLE 5.—*Histopathologic Diagnosis by Category of Findings*

Category	Baseline Phase	Postintervention Phase	Follow-up Phase
Malignant, No. (%)	4 (7)	12 (20)	9 (21)
Benign, No. (%)	7 (12)	11 (18)	6 (14)
Fibroadenoma, No. (%)	16 (27)	16 (26)	13 (30)
Fibrocystic, No. (%)	32 (54)	22 (36)	15 (35)
Total, No. (%)	59 (100)	61 (100)	43 (100)

Discussion

Standardized approaches to clinical decision making are important and should be encouraged, with the caveat that some variations in physicians' practice are appropriate because of differences in patients' symptoms and risks.[15] The decision on how best to manage a patient requires synthesizing information on the incidence of

the disease, a patient's history, risks for the disease, the findings of a physical examination, test results, and an understanding of test limitations.

Mammography is unquestionably an important tool in the early detection of breast cancer, and its findings should be reported in standard descriptive terms. The management of patients with abnormal mammograms requires communication and decision making by teams composed of radiologists, surgeons, the primary care professionals, and the patients.[5,6] This project, through recommendations in the clinical algorithm, encouraged a multidisciplinary approach to the management of patients with abnormal mammograms. The clinical algorithm describes and recommends management decisions on empirically based mammographic characteristics and clinical findings—the rational approach to the early detection of breast cancer that has been recommended.[5]

Study Limitations

This study was limited to those breast biopsy cases preceded by an abnormal mammogram read by the participating radiology medical group. The original design for this study was to determine the number of abnormal mammograms performed by the radiology medical group and to establish PPVs for all abnormal mammograms read by this group. Unfortunately, the computer database of the radiology medical group was unable to provide information in a reliable format, and the study design was converted to accessing the available pathology database and backtracking cases to the radiology database.

The participating hospital pathology department serves several hospitals and surgicenters in the county (San Diego, California), and these geographically distant sites are served by different radiology medical groups. Therefore, most exclusions were because there was no record of mammographic service by the participating radiology medical group. It is estimated that between 80% and 90% of breast biopsies precipitated by an abnormal mammogram read by this radiology medical group were processed by the hospital pathology department over the study periods. Therefore, the data reported do not represent all abnormal mammograms read by this group.

Another limitation may be that the members of this particular radiology group differ from other radiologists. These radiologists may have been more sensitive to medicolegal issues in the baseline phase than other radiologists. There was some variation in case contribution by radiologists over the three study periods; one radiologist retired, and a replacement was hired. There was no statistically significant difference in the number of cases recommended for biopsy, although this may be due to the low power of the study.

The participation of only one radiology group and the lack of data regarding the approximate 10% to 20% of the patients with abnormal mammograms who had biopsies done elsewhere limit the generalizability of the study. Because of the computer database in use during the study periods, information regarding the patient population being screened was unavailable. The mean patient age of those meeting the study criteria did not change significantly over the three study periods, however.

Another limitation of this study was the small sample size. A larger sample size would have improved the statistical power. Unfortunately, measuring medical outcomes is difficult and complex and the problem of insufficient power due to small sample size a common one.[15]

Although a major limitation of this study is the lack of information regarding missed cancers, the lack of statistical difference in the mean lesion size of the cancers is encouraging. Reporting software developed by the American College of Radiology is now in place at the radiology medical group, and valid summary data can be generated. The algorithm has been revised to reflect the multilevel reporting system of the American College of Radiology.

Conclusions and Implications

A statistically significant difference between the PPVs for the baseline and the postintervention phase (4% and 22%, respectively) was found in the subset of cases with a recommendation for biopsy. But whereas this change was associated with the intervention, causality cannot be assumed, given the many limitations of the study. There was no significant difference between the postintervention- and the follow-up–phase PPVs for this subset.

This study's findings suggest that group I surgeons (those involved in the algorithm development) were already practicing in the recommended range of 10% to 30% (baseline, postintervention, and follow-up PPVs of 19%, 11%, and 24%, respectively). The fluctuation in group I's PPVs is probably due to chance because there were no significant differences found. The significant difference found between the preintervention and the postintervention PPVs of group II surgeons, who were exposed only to education and the algorithm, suggests that there may be a subpopulation of surgeons who would benefit from exposure to the clinical algorithm. This finding, however, could also be interpreted that a radiologist's recommendation for biopsy in the baseline phase affected group II surgeons' decision to do a biopsy to a greater extent than it did group I surgeons' decision to do a biopsy.

The results of this study suggest that clinical algorithm development under the leadership of an opinion leader, combined with continuing medical education efforts, may be efficacious in reducing the number of unnecessary surgical procedures.

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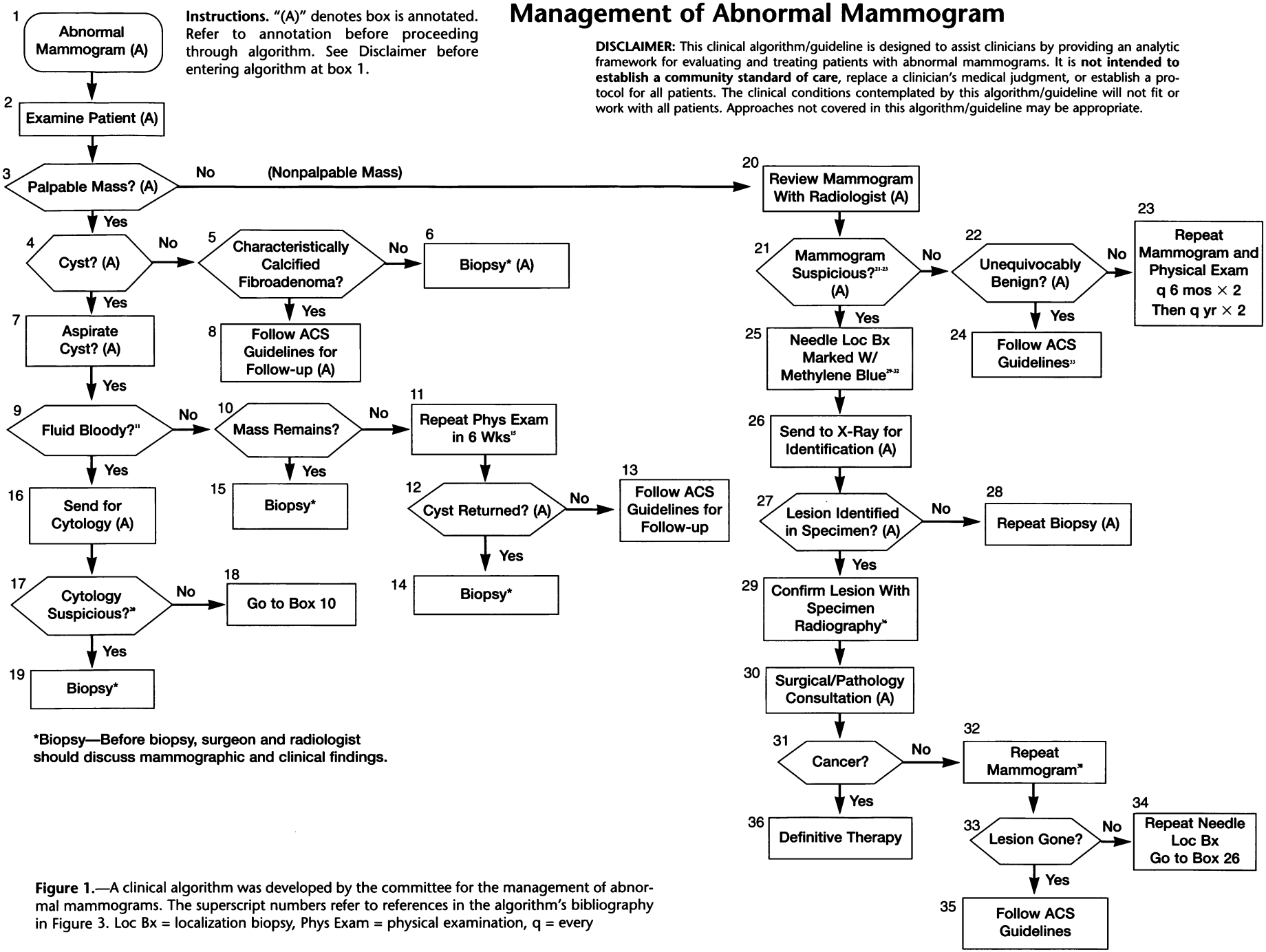
Management of Abnormal Mammogram

Instructions. "(A)" denotes box is annotated. Refer to annotation before proceeding through algorithm. See Disclaimer before entering algorithm at box 1.

DISCLAIMER: This clinical algorithm/guideline is designed to assist clinicians by providing an analytic framework for evaluating and treating patients with abnormal mammograms. It is **not intended to establish a community standard of care**, replace a clinician's medical judgment, or establish a protocol for all patients. The clinical conditions contemplated by this algorithm/guideline will not fit or work with all patients. Approaches not covered in this algorithm/guideline may be appropriate.



*Biopsy—Before biopsy, surgeon and radiologist should discuss mammographic and clinical findings.

Figure 1.—A clinical algorithm was developed by the committee for the management of abnormal mammograms. The superscript numbers refer to references in the algorithm's bibliography in Figure 3. Loc Bx = localization biopsy, Phys Exam = physical examination, q = every

Box 1
- Intended users: primary care practitioners—obstetricians/gynecologists, family practitioners, general practitioners, general internists—radiologists, surgeons, oncologists, pathologists.
- Mammogram should be done at an American College of Radiology (ACR)-accredited facility.
- 90% of cancers are mammographically visible.
- Radiation exposure of the breast after age 45 entails little, if any, risk of radiation-induced breast cancer.[1-6]

Box 2
- Mammogram should be available to the physician at the time of physical examination.
- Where possible, physician should demonstrate examination and lumps to patient with model.
- When possible, physician should recommend low-fat diet to patient.

Box 3
- 10% to 20% of patients with palpable breast cancer have a normal mammogram.[7]

Box 4
- If a lesion is radiologically suspicious for a cyst, recommend radiologist do an ultrasound study.
- A negative ultrasound examination does not exclude a solid mass.
- Ultrasonography is highly accurate in detecting simple and complex cysts.[8,9]

Box 6
- If biopsy findings are benign but mammogram is suspicious for malignancy, repeat mammogram 3 months after biopsy.[10,11]
- Refer to annotation for Box 21.

Box 7
- Decision to aspirate versus not to aspirate should be based on the patient's symptoms, anxiety, clinical examination, or history.[12,13]

Box 8
- American Cancer Society (ACS) guidelines for early breast cancer detection[14,15]:

Breast self-examination:	age ≥20: monthly
Clinical breast examination:	age 20–39: every 3 years age ≥40: yearly
Mammography:	by age 40: baseline ages 40–49: every 1-2 years age ≥50: yearly

Box 12
- It is appropriate to wait for the third postaspiration recurrence before proceeding with biopsy.[11,16]

Box 16
- Refer to your specific laboratory for specimen-handling requirements.

Box 20
- ACR board-certified radiologist who reads a minimum of 480 studies per year. (This is a requirement for radiologists interpreting studies at any ACR-accredited mammography facility.)

Box 21
1. Suspicious microcalcifications
   a. Pleomorphic, heterogeneous, or granular calcifications. Fine or branching (casting calcifications)
   b. Clustered
   c. Indistinct or amorphous
2. Dominant mass
   a. Solid or complex (on ultrasonography)
   b. Spiculated margins
   c. Indistinct margins
   d. Obscured margins
   e. Microlobulated margins
   f. Interval change (increase) in size
3. Distortion of architectural pattern
   a. Asymmetry of parenchyma (seen on 2 views) with central increased density
   b. "Starburst" pattern (a stromal reaction, no mass necessary)
   c. Distortion of architectural pattern (without history of surgery)
4. Skin changes
   a. Skin thickening (seen in inflammatory carcinoma)
   b. Skin puckering[18-24]

Box 22
1. Unequivocally benign[25-28]
   a. Simple benign cysts
   b. Classic features of sedimented calcium within a tiny benign cyst
   c. Dermal calcifications (even if clustered)
   d. Characteristically calcified fibroadenomas
   e. Arterial calcification
   f. Dystrophic and/or sutural postoperative calcification
   g. Intraductal or periductal calcifications of benign ductal ectasia
   h. Discrete masses, entirely or partially fatty
   i. Masses that are typical in size, shape, and location for intramammary lymph nodes

Box 23
Probably benign lesions (0.5% incidence of cancer)[29-32]
1. Localized
   a. Clusters of tiny calcifications—≥5 calcific particles per cm^3—if fine-detail images showed that all of the particles were round or oval
   b. Noncalcified solid nodules—no size limitation, but nonpalpable—with round, ovoid, or gently lobulated contours and well-defined margins not obscured by adjacent breast tissue
   c. Selected focal asymmetric areas of fibroglandular density—no size limitation, but nonpalpable—defined as discrete opacities readily visible on 2 orthogonal projections, with concave-outward margins and/or interspersed with fat
   d. Single dilated duct (if not associated with spontaneous nipple discharge)
   e. Subtle areas of architectural distortion without central increased density (when occurring at known biopsy sites)
2. Generalized (3 or more similar lesions)
   a. Microcalcifications
      i. Multiple discrete clusters of calcification
      ii. Numerous bilateral scattered and randomly clustered calcifications
   b. Nodules randomly distributed in both breasts showing similarity of the component parts of such scattered lesions

Any change in these lesions after 6 months that raises the slightest suspicion of malignancy at the 6-month, 1-year, 2-year, and 3-year follow-up studies prompts immediate biopsy.

Box 26
- Specimen mammography to confirm the presence of suspicious lesion within biopsy.[31,33,34]

Box 27
- It is important to correlate radiographic and pathologic findings.[35]

Box 28
- Immediate re-excision of suspected area.
- If still negative, close incision and repeat mammogram in 3 mos (6 weeks if microcalcification present).

Box 30
- Specimen radiograph to accompany specimen to pathology.[37]
- Evaluate tissue margins.[37]
- Estrogen and progestogen receptor and DNA studies.[37]

Figure 2.—These annotations were compiled to supplement the clinical algorithm. The superscript numbers refer to references in the algorithm's bibliography in Figure 3.

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Figure 3.—This bibliography accompanied and supplemented the clinical algorithm and annotations.